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TOWARDS DEVELOPMENT OF A RUBBER INFORMATION SYSTEM

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ABSTRACT

Remote sensing has been directly responsible for major advances in our understanding and ability to manage agriculture, forestry and water resources. Some work in this applied research as far as rubber is concerned was done earlier. It is now possible to have a rubber plantation distribution map of a given geographic area that could be used as one layer in the Geographical Information System. Resource map of soils under rubber in traditional region is already prepared that could be used as another theme. Earlier report is available regarding the combined application of remote sensing and GIS regarding the separation of soils under rubber. Other layers related to rubber also could be generated and brought into the environment of GIS for other activities like disease map, clonal distribution etc.

Another aspect called DEM (digital elevation model) is assuming importance in site-specific management. A DEM is a digital representation of the relief of the earth's surface Typically it consists of arrays and values that represent topographical elevations measured at equal intervals on earth's surface. Reports are available regarding the possible applications of DEM in planning of planting terraces, computation of site yield potentials, production of soil erosion risk map etc. Similarly, there were attempts to improve planting and development in hilly terrain and implementation of fieldwork through the use of DEM.

In the present article the work regarding the application of remote sensing in delineating rubber plantations from other types of vegetation is discussed. An already available soil map was shown as another layer that can be brought into the GIS environment. The digital elevation model of the study area was generated using a software, 3DEM. Draped images of supervised classification map and soil map in three-dimensional view are shown. It is possible to develop a database with different layers of information related to rubber cultivation to create a Rubber Information System (RIS) that can work as a decision support system.

INTRODUCTION

Holding a PDA (personal digital assistant) in the palm for data entry, retrieval and analysis, and taking a quick decision is a dream for an Indian planter at present. A number of PDAs or other palmtops can be integrated with a desktop computer to store and display reports and data from databases, accounting information, digital maps, simulation models, expert systems, schedules and other basic data relevant to the planter's day-to-day operations. This imagination can become a reality with the availability of ever changing Information Technology. However, there is every need to develop first a database that forms the basis in decision-making. It needs some more time to reach this sophistication in India in general and in rubber plantation in particular since the theme wise database generation had just began. Rubber Research Institute of India made a unique attempt in the country to get the soils under rubber in Kerala and Tamil Nadu mapped in 1:50000 scale (NBSS & LUP, 1999) in the direction of developing the theme wise database.

Remote sensing has been directly responsible for major advances in our understanding and ability to manage agriculture, forestry and water resources. Rao and Pothen, (1995) outlined some of the possible applications of remote sensing in rubber cultivation. Some work in this direction was dome by Rao *et al.*, (2000) who studied the spectral reflectance during leafless period, developing and developed stages of canopy that would help in discriminating rubber from other types of vegetation since rubber has got a unique shedding behaviour called wintering.

It is possible now to have a rubber plantation distribution map of a given geographic area that could be used as a layer in the GIS, in addition to the other layers, for instance the soil map already prepared. Similarly, other layers related rubber could be generated and brought into the environment of GIS for other activities. A volume of literature is available with regard to the applications of GIS in different spheres. Fairhumt *et al.*, (2000) described the potential applications of use of GIS in plantation agriculture. In a test application Rao *et al.*, (2001) integrated RS and GIS to separate soils under rubber plantations from non-rubber areas.

With the background of this information it is presumed that it is possible to develop a database including all the spatial information related to rubber and its cultivation by combining both RS and GIS. Another aspect called DEM (digital elevation model) is assuming importance in site-specific management. A DEM is a digital representation of the relief of the earth's surface. Typically it consists of arrays and values that represent topographical elevations measured at equal intervals on earth's surface. The possible applications of DEM include planning of planting terraces, computation of site yield potentials, production of soil erosion risk map etc. Tey *et al.* (2000) discussed about attempts to improve planting and development in hilly terrain and implementation of fieldwork through the use of DEM. The present article is about an exercise that was taken up for digital image processing for rubber map, GIS to integrate soil map with rubber map and DEM for understanding the retain of the study area the results of which are discussed in the text to follow.

MATERIALS AND METHODS

An area called Cheruvally Estate area in the Kottayam district of Kerala was selected as the study area. This area consisted of rubber plantations both in estate and small holding sectors, mixed forest and teak plantations. The digital data of IRS-IC (Indian Remote sensing Satellite - 1C) pertaining to the above area (falls in Path 100 and row 67) of 7 February 1997 was used in the present study. This image was geometrically corrected using an IRS-1B geocoded image of the same area (29-01-1997) as the reference. A supervised classification of the study area with maximum likelihood classifier was performed on the image using the training sites, which were verified, in the ground truth survey. A total of six signatures were developed, two for rubber based on the reflectance and one each for teak, mixed forest, river & shallow waters and others (which mainly include bare lands). The digital image was processed using IDRISIW version 2.0 and ground truth survey was conducted on 7-02-1997.

A soil map of the corresponding area in 1:50000 scale was extracted from the soil maps published by NBSS&LUP (1999). This piece of soil map and the contours with reference to the corresponding toposheet in 1:50,000 scale were digitized using the software, Mapinfo. This X, Y (co-ordinates) and Z (elevation) information was converted into ASCII text file. This text file was used as an input for the software 3DEM for generating the third dimension of the study area. The bitmaps of classified image and soil map were draped on this 3D map for visualization of the terrain for interpretation.

RESULTS AND DISCUSSION

The classified image shown in figure 1 showed that there were six classes identified based on the training statistics including tow classes of rubber based on spectral reflectance. The visual interpretation of the classified image showed that the classification was satisfactory (Rao, 2000) with some minor discrepancies. Rao *et al.*, (2001) reported similar study pertaining to another rubber growing area Mooply Valley in Thrissur district of Kerala. It is understood that rubber separation is possible by using LISS-III data of IRS-IC that has got a good resolution of 23 meters. Further study by Rao (2000) included temporal variations in spectral reflectance from rubber during no leaf period, developing and developed canopy since rubber has a leaf shedding behaviour, which is called 'wintering'. This information helps in decisively separating rubber from teak and mixed forest that are the other major plantation activity in Kerala. Coconut has a typical spectral reflectance that in any case does not interface in identifying rubber (unpublished). It is imperative from the study that application of remote sensing is an easier and more efficient viable tool in generating a rubber distribution map of any given area at a given level of scale.

Fig. 2 showed the soil map of the study area extracted from already prepared soil maps of the traditional rubber growing areas (NBSS&LUP, 1999). Various soil series associations were identified in the study area the details of which are given in Table 1. It could be seen that the soil series associations were of different combinations and proportions of soil series identified. Soil series 'Agl' and 'Ipr' were Ustic Palehumults, while 'Tvr', 'Cvl', 'Mnm' and 'Tkd' were Ustic Kanhaplohumults. The soil series 'Lah' also was

Ustic Kanhaplohumults but with clayey texture. The other series namely 'Ktd', 'Knm' and 'Tpl' were Ustic Haplohumults and 'Kpl' was Ustic Kandihumults. Though the soil series 'Plg' and 'Vpm' also were Ustic Knadihumults, the texture was clayey in the control section. The soils of 'Tbm' and 'Kgl' series were Ustic Humitropepts (NBSS&LUP, 1999). A volume of literature is available on combined utilities of remote sensing and GIS in several fields. As far as utilization of these modern tools in rubber cultivation is concerned, separation of soils under rubber from non-rubber areas was reported by Rao (2001) using both remote sensing and GIS techniques to know more precisely the soils supporting rubber. Technically it is possible to develop some other themes like distribution of rubber clones that vary in spectral reflectance, maps of diseases of rubber etc and to bring these themes into GIS environment not only for preparation of maps but also for spatial analysis.

The digital elevation model of the study area is shown in the Fig. 3. The terrain could be visualized with the help of 3D projection. In addition of this, 3DEM also has the capability of showing flying model of the terrain. Fig. 4 showed the classified image draped on the DEM, which gave different land covers with their elevation information. Similarly, Fig. 5 indicated the draped soil map on 3D image of the area showing different types of soils (shown table 1) in the study area in third dimension also. Three-dimensional view of terrain is a modern tool, which can be used in landscape management showing the topography in maps. In the past, three-dimensional maps were laboriously constructed for many other purposes.

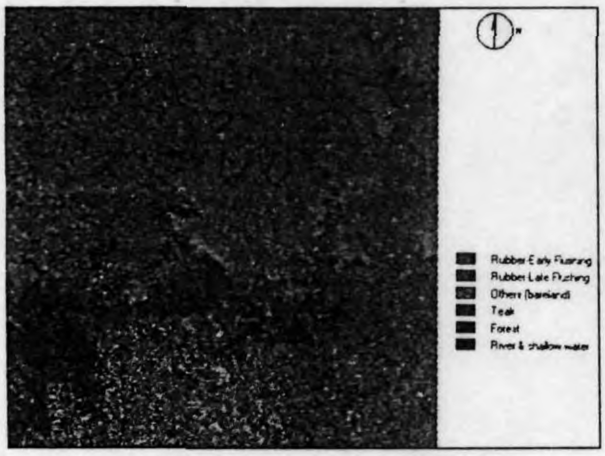

Fig. 1. Classified image of Cheruvally Estate Area

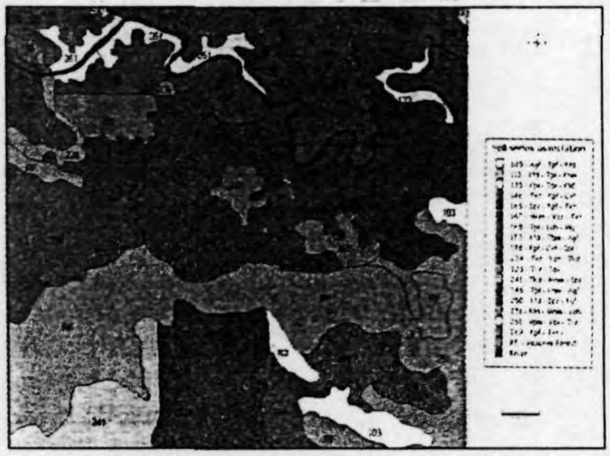

Fig. 2. Soil map of Cheruvally Estate Area

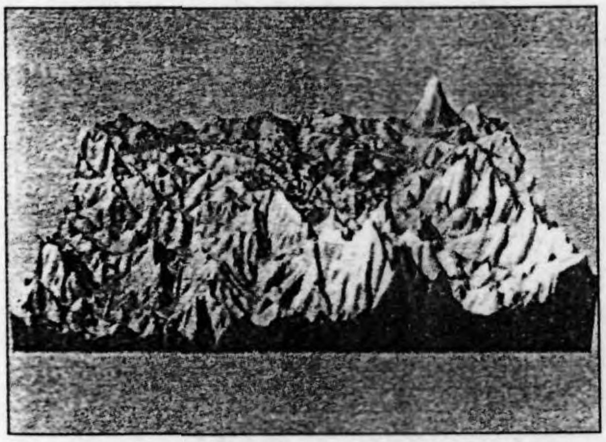

Fig. 3. Digital elevation model of Cheruvally Estate Area

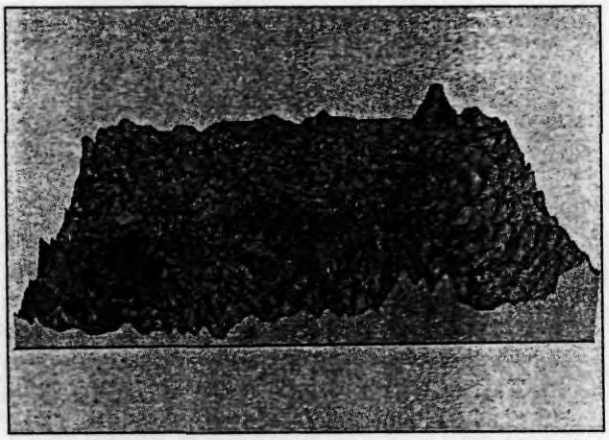

Fig. 4. Classified image draped on DEM of Cheruvally Estate Area

Table 1. Soils in the study area

Map symbol	Soil series association	Description
103	Agl-Tpl-Ktd (slope 25-33%)	Clayey-skeletal, kaolinitic, isohyperthermic Ustic Palehumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Haplohumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Haplohumults
113	Ktd-Tpl-Knm (slope 25-33%)	Clayey-skeletal, kaolinitic, isohyperthermic Ustic Haplohumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Haplohumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Haplohumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Haplohumults
133	Kpl-Tpl-Ktd (slope 15-25%)	Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kandihumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Haplohumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Haplohumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Haplohumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Haplohumults
146	Tvr-Kpl-Cvl (slope 15-25%)	Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kanhaplohumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kandihumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kanhaplohumults
166	Ipr-Kpl-Tvr (slope 15-25%)	Clayey-skeletal, kaolinitic, isohyperthermic Ustic Palehumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kandihumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kanhaplohumults
167	Mnm-Tpl-Tvr (slope 15-25%)	Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kanhaplohumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Haplohumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kanhaplohumults
168c	Tpl-Lah-Plg (slope 15-25%)	Clayey-skeletal, kaolinitic, isohyperthermic Ustic Haplohumults - Clayey, kaolinitic, isohyperthermic, Ustic Kanhaplohumults - Clayey, kaolinitic, isohyperthermic, Ustic Kandihumults
173	Ktd-Tbm-Agl (slope 15-25%)	Clayey-skeletal, kaolinitic, isohyperthermic Ustic Haplohumults - Loamy-skeletal, kaolinitic, isohyperthermic Ustic Humitropepts - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Palehumults
198	Kpl-Cvl-Ipr (slope 10-15%)	Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kandihumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kanhaplohumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic kanhaplohumults
224	Tvr-Vzr-Tkd (slope 10-15%)	Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kanhaplohumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kanhaplohumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kanhaplohumults
226	Tvr-Tpl (slope 10-15%)	Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kanhaplohumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Haplohumults
241	Tkd-Mnm-Ipr (slope 10-15%)	Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kanhaplohumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kanhaplohumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kanhaplohumults

Map symbol	Soil series association	Description
246	Tpl-Knm-Agl (slope 10-15%)	Clayey-skeletal, kaolinitic, isohyperthermic Ustic Haplohumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Haplohumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Palehumults
250	Ktd-Ipr-Kgl (slope 10-15%)	Clayey-skeletal, kaolinitic, isohyperthermic Ustic Haplohumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kanhaplohumults - Loamy-skeletal, kaolinitic, isohyperthermic Ustic Humitropepts
251	Ktd-Mnm-Lah (slope 10-15%)	Clayey-skeletal, kaolinitic, isohyperthermic Ustic Haplohumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kanhaplohumults - Clayey, kaolinitic, isohyperthermic, Ustic Kanhaplohumults
261	Vpm-Kpl-Tvr (slope 5-10%)	Clayey, kaolinitic, isohyperthermic Ustic Kandihumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kandihumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kanhaplohumults
269	Kpl-Tvr (slope 5-10%)	Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kandihumults - Clayey-skeletal, kaolinitic, isohyperthermic Ustic Kanhaplohumults

Agl = Angle Valley; Tpl = Tulappally; Ktd = Koruthode; Knm = Kunnam; Kanjirappally; Tvr = Thiruvanchoor; Cvl = Cheruvally; Ipr = Ittiyappara; Mnm = Manimala; Lah = Lahai; Tbm = Thombikandom; Vzr = Vazhoor; Tkd = Thambalakkad; Kgl = Kottangal; Vpm = Vijayapuram

But with the advent of computer technology, creation of 3D image is made easy once the elevation data is available. This approach is employed in most GIS and terrain visualization software and 3DEM is such a programme. This three dimensional visualization has got definite advantages in plantation management activities. The possible applications of DEM include planning of plating terraces, computation of site yield potentials, production of soil erosion risk map etc. Tey *et al.*, (2000) discussed about the attempts to improve planting and development in hilly terrain and implementation of fieldwork through the use of DEM.

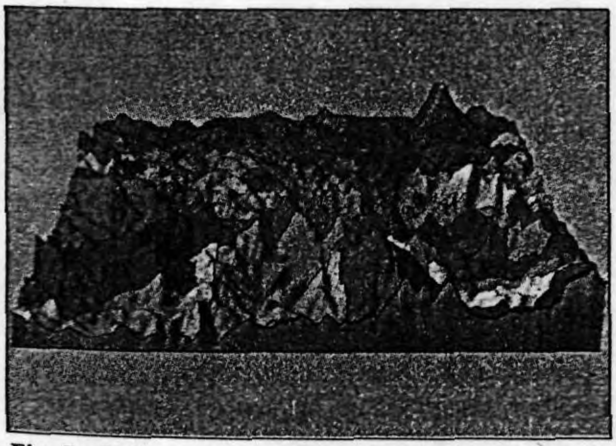

Fig. 5. Soil map draped on DEM of Cheruvally Estate Area

CONCLUSIONS

It is seen practically that the available technology helps both development and management of a database on aspects related not only to rubber cultivation but also to any aspect of interest linked to rubber and geography leading to an integrated Rubber Information System (RIS). Combined utilization of remote sensing and GIS technologies surely helps in development and updating of the database. It is needless to state the importance of a database in research and in planning to keep the rubber plantation industry viable since the management is dependent on facts but not fancies. It is time to use modern technological tools for effective information system.

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TISSUE CULTURE PROPAGATION OF RUBBER (*HEVEA BRASILIENSIS* (WILLD. EX ADR. DE JUSS.) MUELL. ARG.) CLONE GT (GONDANG TAPEN) 1.

M. P. Asokan, P. Sobhana, S. Sushamakumari and M. R. Sethuraj

Asokan, M. P., Sobhana, P., Sushamakumari, S. and Sethuraj, M. R. (1988). Indian J. Nat. Rubb. Res. 1(2): 10–12.

An *in vitro* propagation system for clone GT 1 is reported. The optimal growth regulator range for shoot and root development was 1.5 - 3.0 mg l^{-1} indoleacetic acid (IAA) with 0.5 - 1.5 mg l^{-1} kinetin. Rooted plantlets were successfully transplanted in the field.

Key words – *Hevea brasiliensis*, Tissue culture, *In vitro* propagation.

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INTRODUCTION

Hevea brasiliensis (Willd. ex Adr. de Juss.) Muell. Arg., the commercial source of natural rubber can be propagated generatively and vegetatively. Traditionally clonal materials are multiplied by budgrafting. Natural rubber producing countries have been experiencing the need, for quite some time, for a tissue culture propagation system for rubber clones. It is reasonably assumed that tissue culture derived rubber clones would have the possibility of bigger trunk-girth causing earlier tapping and that they would be devoid of the disadvantages, usually associated with the traditional propagation system, such as stock-scion interaction resulting in high coefficient of variation among trees. Paranjothy and Ghandimathi (1975 a and b) could grow shoot tips from 2–4 weeks old seedlings. They could induce rooting also among some of the seedling-derived cultures but failed to do so with clonal materials. Shoots have been regenerated from auxiliary bud explants of a few *Hevea* clones by Sinha *et al.* (1985) but failed to obtain rooting. However, shoot and root development were successfully obtained from seedlings by Carron *et al.* (1988).

MATERIALS AND METHODS

Shoot apices were excised from GT 1 clonal trees and were surface sterilized for 5 min in 70 per cent alcohol with 1.0 per cent Tween 20 followed by immersion in 1.0 per cent sodium hypochlorite for 8 min and thorough rinsing in sterile double distilled water. With the aid of a dissection microscope, 3–5 mm shoot apices were excised and placed in the culture tubes (15 x 2.5 cm) containing 10 ml of AH–I medium (medium standardised in this laboratory) per tube. The concentration of Bacto Agar (BA) was 8.0 g l^{-1}. The pH was adjusted to 5.7 prior to autoclaving for 15 min at 1.01 kg cm^{-2} and 121°C. Kinetin and indole acetic acid (IAA) were added in the medium at the following concentrations : 0 – 5 mg l^{-1} IAA in combination with 0 – 5 mg l^{-1} kinetin, both in increments of 0.5 mg l^{-1}

(all possible combinations). The IAA plus kinetin combinations had 121 x 3 explants in 3 replications. Three tests were conducted. Cultures were maintained at 23°C (± 2) for 3 months under a light regime of 16 h light (1.5 klx) using cool white fluorescent bulbs.

RESULTS AND DISCUSSION

Explants displayed marked differences in their response to different growth regulator combinations. The first visible sign of explant enlargement was observed 3–5 days after inoculation followed by leaf and shoot elongation during subsequent weeks. Rhizogenesis was generally observed 6–8 weeks after inoculation. Tap root emerged first (Fig. 1). Secondary roots developed only 4–5 weeks after tap root emergence. Shoot development was observed in almost all cultures irrespective of the range of growth regulators, except at 0 level of kinetin. This indicates the adequacy of endogenous/exogenous growth regulators for shoot development. However, rhizogenesis was limited to specific hormonal combinations. The maximum rooting of shoots was observed within the growth regulator range of 1.5–3.0 mg l^{-1} IAA with 0.5 – 1.5 mg l^{-1} kinetin (Table 1). IAA in the range of 3.5 – 4.0 mg l^{-1} displayed only a very few cultures having roots. But no rooting was observed beyond 4.0 mg l^{-1} IAA level, presumably due to the inhibitory effect of higher concentrations. The absence of IAA (0 level) alone had no effect on leaf and shoot development. The absence of IAA and

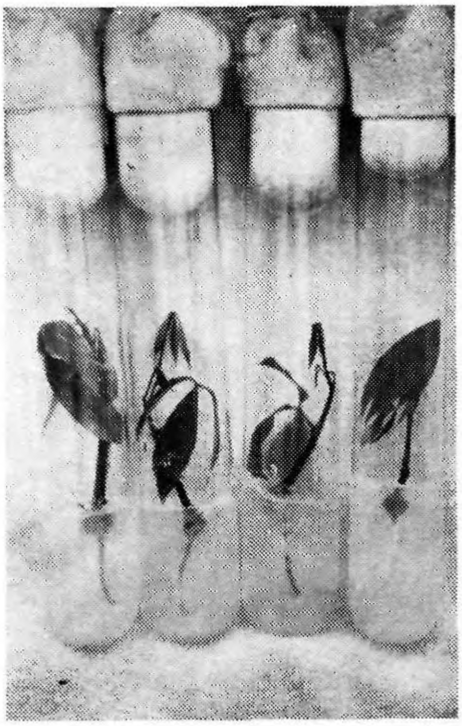

Fig. 1. Rhizogenesis of *Hevea* clone, GT1

Table 1. Effects of kinetin and IAA on rhizogenesis of shoots of rubber clone, GT 1.

Kinetin (mg l^{-1})	IAA (mg l^{-1})				
	0	1.5	2.0	2.5	3.0
0					
0.5	3	31 (± 26.2)		42 (±28.2)	
1.0			52 (± 44.3)	71 (±24.4)	68 (±21.8)
1.5				42 (±64.2)	

Note:– The means (± SD) of number of rooted shoots are from pooled data of three tests (figures were rounded off to eliminate decimals). Only means (± SD) above 30 are recorded in the table.

BA (0 levels) resulted in the lack of growth and eventual death of the cultures. The absence of BA (0 level) also caused similar results. The hardening process of tissue culture derived *Hevea* plant is very critical (Leconte and Carron, 1988). Humidity, temperature and composition of the transplanting medium were found very crucial to the successful hardening process. Humidity was gradually reduced and temperature increased during 3 to 4 weeks of this process. Potting mixture was composed of equal sand: soil (v/v) mixture.

Reports on *in vitro* propagation systems for tree crops are fewer than those for horticultural crops. The results of this study demonstrated that *in vitro* propagation of clone GT 1 is possible. A few other *in vitro* systems also have been developed by us for the propagation of other commercial clones (unpublished).

The sucessfully hardened plants were transplanted in the field (Fig. 2). The rate of survival of such plants was 93.0 per cent.

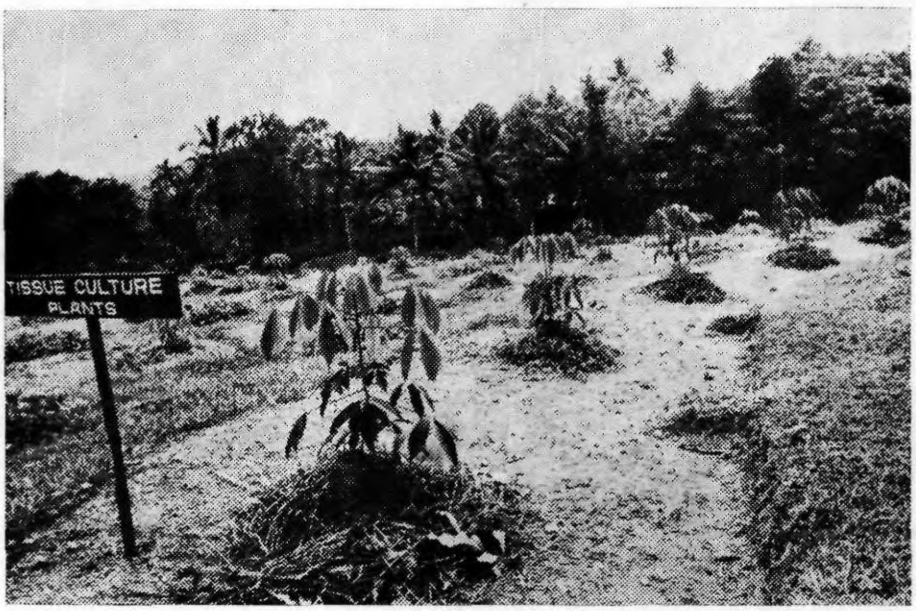

Fig. 2. Tissue culture derived plants growing in the field.

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